

United States Department of Agriculture
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

CHEMICAL AND PHYSICAL PROPERTIES OF
ORGANIC PHOSPHORUS INSECTICIDES

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Several organic phosphorus compounds have recently come into use as insecticides, and a number of others have been proposed for this purpose. The physical and chemical properties of these compounds are presented herein for the guidance of investigators working with them. The information has been compiled from the literature, from data supplied by manufacturers, and from measurements made in this laboratory. Only the compounds that are now in commercial use or are being tested extensively are included.

All these compounds are highly toxic to man, and caution should be used in handling them.

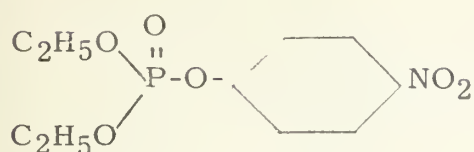
Literature Cited

- (1) Hall, S. A.
1950. Methyl homolog of parathion. Amer. Chem. Soc. Jour.
72: 2768-2769.
- (2) _____ and Jacobson, M.
1948. Hexaethyl tetraphosphate and tetraethyl pyrophosphate.
Ind. Eng. Chem. 40: 694-699.
- (3) Schrader, G. S.
1951. Die Entwicklung neuer Insectizide auf Grundlage
organischer Fluor- und Phosphor-verbindungen.
Monograph No. 62, p. 52. Verlag Chemie, GMBH,
Weinheim, Germany.
- (4) Toy, A. D. F.
1948. Preparation of tetraethyl pyrophosphate and other tetraethyl
pyrophosphates. Amer. Chem. Soc. Jour. 70: 3882-3886.

	O,O-Diethyl O- <u>p</u> -nitrophenyl thiophosphate	O,O-Dimethyl O- <u>p</u> -nitrophenyl thiophosphate
Structural formula. . .	$\begin{array}{c} \text{C}_2\text{H}_5\text{O} \quad \text{S} \\ \quad \quad \parallel \\ \quad \quad \text{P} - \text{O} - \text{C}_6\text{H}_4 - \text{NO}_2 \\ \quad \quad \diagup \\ \text{C}_2\text{H}_5\text{O} \end{array}$	$\begin{array}{c} \text{CH}_3\text{O} \quad \text{S} \\ \quad \quad \parallel \\ \quad \quad \text{P} - \text{O} - \text{C}_6\text{H}_4 - \text{NO}_2 \\ \quad \quad \diagup \\ \text{CH}_3\text{O} \end{array}$
Other names	Parathion, E-605	Methyl parathion, methyl hexamethyleneparathion
Empirical formula . . .	C ₁₀ H ₁₄ NO ₅ PS	C ₈ H ₁₀ NO ₅ PS
Molecular weight. . .	291	263
Phosphorus content . .	10.63%	11.78%
Physical state	Pale-yellow liquid	White crystalline solid
Melting point.	6.0°C.	35°(1) ^{1/} , 36°C.(3) ^{1/}
Boiling point	157-162°C. at 0.6 mm.
Specific gravity	1.2655 at 25°/4°C.	1.358 at 20°/4°C.
Refractive index	n _D ²⁵ 1.5370	n _D ³⁵ 1.5515
Solubility in water . . .	15-20 p.p.m. at 20-25°C.	50 p.p.m. at 25°C.
Hydrolysis rate	Very slow at pH 7 and below. Half-life 120 days at 25°C. Very rapid above pH 7. Half-life 8.6 min. in N/1 alkali at 30°C.	Stable for several days in natural water. Very rapid in alkaline solution. Half-life approximately 2.5 min. in N/1 alkali at 30°C.
	Tetraethyl pyrophosphate	Tetraethyl dithiopyrophosphate
Structural formula. . .	$\begin{array}{c} \text{C}_2\text{H}_5\text{O} \quad \text{O} \quad \text{O} \quad \text{OC}_2\text{H}_5 \\ \quad \quad \parallel \quad \parallel \\ \quad \quad \text{P} - \text{O} - \text{P} \\ \quad \quad \diagup \quad \diagdown \\ \text{C}_2\text{H}_5\text{O} \quad \text{OC}_2\text{H}_5 \end{array}$	$\begin{array}{c} \text{C}_2\text{H}_5\text{O} \quad \text{S} \quad \text{S} \quad \text{OC}_2\text{H}_5 \\ \quad \quad \parallel \quad \parallel \\ \quad \quad \text{P} - \text{O} - \text{P} \\ \quad \quad \diagup \quad \diagdown \\ \text{C}_2\text{H}_5\text{O} \quad \text{OC}_2\text{H}_5 \end{array}$
Other names	TEPP (commercial preparation containing about 40% of tetraethyl pyrophosphate)	Sulfotepp, dithio, tetraethyl pyrophosphate
Empirical formula . . .	C ₈ H ₂₀ O ₇ P ₂	C ₈ H ₂₀ O ₅ P ₂ S ₂
Molecular weight. . .	290	322
Phosphorus content . .	21.36%	19.25%
Physical state	Colorless liquid	Yellow to colorless oil
Melting point.
Boiling point.	104-110°C. at 0.08 mm.	110-113°C. at 0.2 mm.
Specific gravity	1,1810 at 25°/4°C.	1,196 at 25°/4°C.
Refractive index	n _D ²⁵ 1.4170 (2) ^{1/} , 1.4180 (4) ^{1/}	n _D ²⁵ 1.4753
Solubility in water . . .	Completely miscible	670 p.p.m.
Hydrolysis rate	Rapid in neutral water; half-life at 25°C. 6.8 hours; at 38°C. 3.3 hours Very rapid in alkaline solution	Very stable

phenyl

Diethyl p-nitrophenyl phosphate



analog of

Para-oxon, E-600, oxygen analog of parathion

$C_{10}H_{14}NO_6P$

275

11.26%

Reddish-yellow liquid

148-151°C. at 1 mm.

1.269 at 25°/25°C.

n_D^{25} 1.5060

2500 p. p. m. at 25°C.

Very slow at pH 7

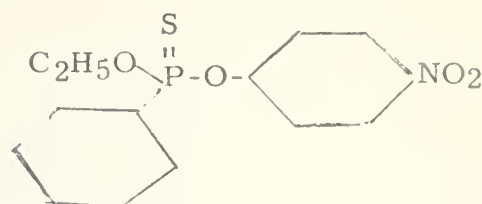
neutral

ane

imately

C.

O-Ethyl O-p-nitrophenylbenzene
thiophosphonate



EPN, ethyl p-nitrophenyl thiono-
benzenephosphate

$C_{14}H_{14}O_4NPS$

323

9.59%

Off-white crystals

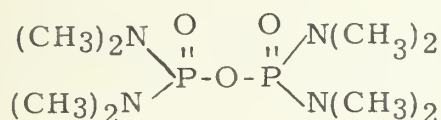
36°C.

Essentially insoluble

Stable at pH 7 and below; slow
above pH 7

phate

Octamethyl pyrophosphoramidate



thiono-

OMPA, schradan

$C_8H_{24}N_4O_3P_2$

286

21.65%

Colorless liquid

118-122°C. at 0.3 mm.

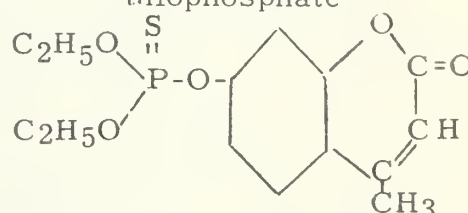
1.1343 at 25°/4°C.

n_D^{25} 1.4612

Completely miscible

Rapid in strong acid solution and very
slow in neutral and alkaline solutions

O,O-Diethyl 4-methylumbelliferone
thiophosphate



Diethyl thiophosphoric acid ester
of 7-hydroxy-4-methyl coumarin,
E-838

$C_{14}H_{17}O_5PS$

328

9.44%

Fine white crystals

36°C.

1.260 at 38°/4°C.

n_D^{37} 1.5685

Very slightly soluble

Very slow

O,O-Dimethyl dithiophosphate of diethyl mercaptosuccinate	$ \begin{array}{c} \text{S} \\ \parallel \\ \text{CH}_3\text{O}-\text{P}-\text{S}-\text{CH}-\text{C}-\text{OC}_2\text{H}_5 \\ \parallel \quad \parallel \\ \text{CH}_3\text{O} \quad \text{O} \\ \quad \quad \text{CH}_2-\text{C}-\text{OC}_2\text{H}_5 \end{array} $	Bis(isopropylamido)fluorophosphate	$ \begin{array}{c} \text{O} \\ \parallel \\ (\text{CH}_3)_2\text{N}-\text{P}-\text{F} \\ \quad \quad \parallel \\ (\text{CH}_3)_2\text{N} \end{array} $
Structural formula		Bis(dimethylamido)fluorophosphate	
Other names	S-(1,2-dicarbethoxyethyl) O,O-dimethyl dithiophosphate, malathon, 4049	Isopestox (a trade name for formulations containing this compound)	Schrader's #13/28
Empirical formula	C ₁₀ H ₁₉ O ₆ PS ₂		C ₄ H ₁₂ FN ₂ OP
Molecular weight	330		154
Phosphorus content	9.38%		20.10%
Physical state	Deep brown to yellow liquid		Colorless liquid
Melting point	-7°C.		67°C. at 4 mm.
Boiling point	156-157°C. at 0.7 mm. (slight decomposition)		
Specific gravity	1.23 at 25°/4°C.		
Refractive index	25 1.4985		
Solubility in water	145 p.p.m.		Completely miscible
Hydrolysis rate	Hydrolyzes above pH7. Stable at pH 7 and lower		Stable in neutral water